EML

Environmental Measurements Laboratory

"A Federal Resource"

In Situ Spectrometry

The scope of environmental cleanup taking place within the DOE and elsewhere necessitates rapid measurement techniques of radioactive contaminants during site characterization work as well as certification of areas following remediation. *In situ* gamma-ray spectrometry is a technique that provides information on the concentrations and associated dose rates for specific radionuclides that are present in soil and building materials. As the leading developers of this technique over the years, EML is active in promoting its use through consultation, training, demonstrations, and intercalibration exercises. EML also continues to develop new applications and analytical procedures that can be applied to radiological surveys. These efforts have led to implementation of *in situ* spectrometry at the Fernald Environmental Management Project and should ultimately lead to wide-scale deployment across the DOE complex.

Advantages

A typical measurement for a radioactive contaminant using a soil sampling approach requires collection, processing and laboratory-based analysis which is time consuming and has the potential to generate waste. Furthermore, it provides a measurement of only a few kilograms or less of soil. In comparison, an *in situ* measurement is non-intrusive and non-destructive and can take only minutes to make. The result is immediately available for interpretation. Moreover, it provides an average over several thousand kilograms of soil. In many situations, *in situ* spectrometry provides a highly cost effective technique for characterizing and certifying lands with actual or potential residual radioactivity.

Recent Training and Demonstrations by EML

- IAEA/USEPA Workshop on Environmental Radiation Measurements Using Spectrometric Techniques (1998)
- Brookhaven National Laboratory (1997)
- Fernald Environmental Management Project (1996)
- Canberra Users Group Meeting (1995, 1997)
- Weldon Spring Remedial Action Project (1995)
- Russian 3rd Environmental Remediation Course, Site Characterization Group (1995)
- IEEE Nuclear Science Symposium Short Course Program (1991, 1993, 1994, 1995)
- U.S. Nuclear Regulatory Commission (1994)

Detector Calibration

EML has developed specialized equipment and computer software for accurate calibrations of HPGe detectors for *in situ* spectrometry. Detectors can be calibrated for a variety of nuclides subject to a wide range of environmental conditions. Shown at the left is the evaluation of a HPGe detector using EML's calibration bench. This bench has platforms that feature translational and rotational capability for precise positioning of detectors, radiation sources and shielding.

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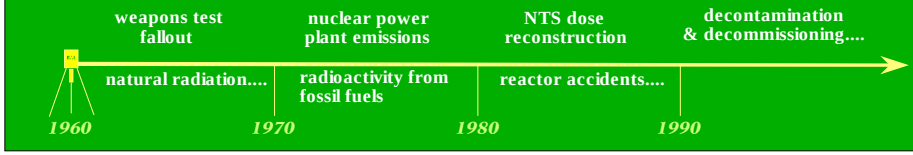
History of *In Situ* Spectrometry Applications at EML



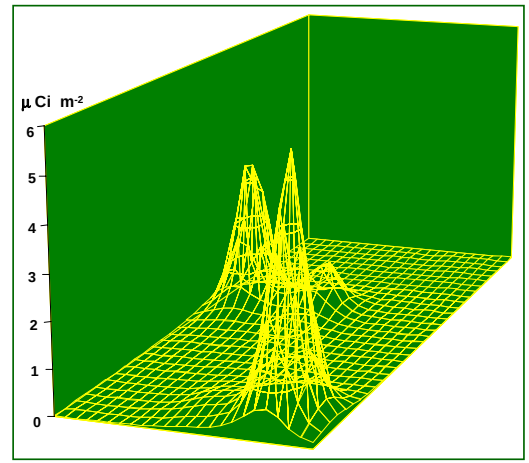
EML Participation in Standards Development

- ICRU Report No. 53, "Gamma-Ray Spectrometry in the Environment."
- IEEE N42.RM, "Characterization of Germanium Detectors for *In Situ* Spectrometry"
- IEC 61275, "*In Situ* Photon Spectrometry System Using A Germanium Detector"

Analysis of Measurements on a Grid

Radiological surveys frequently require measurements performed at fixed distances along a grid. Where the spacing of *in situ* measurements is on the order of a few meters or less, the resultant overlapping pattern in the detector viewing area allows a mathematical technique such as deconvolution (sometimes called unfolding) to be applied. For interpreting such data, EML has developed a computer code based on the principle of maximum entropy. The results allow a reconstruction of localized areas of potential elevated radioactivity levels, which can then be further investigated. A highly relevant application of this technique is for release surveys where some assurance is needed that there are no "hot spots" of contamination left behind.

The illustration below shows the results of deconvolution where two ^{137}Cs sources were used to simulate two separate elevated areas of contamination. To generate this map, a total of 12 spectra were collected on a 4 by 3 grid measuring 2 meters on a side. The peaks give the approximate position and magnitude of the potential source distribution. Further analysis is used to provide a more precise position and magnitude.



Recent EML Publications

- "Fluence Evaluations For Applications of *In Situ* Gamma-Ray Spectrometry in Non-Flat Terrain," USDOE Report EML-603 (1999)
- "An Alternative Approach to Hot Spot Identification Using *In Situ* Spectrometry Measurements on a Grid," Health Physics 74, 481-485 (1998)
- "A Computer Program to Analyze Data from a Series of *In Situ* Measurements on a Grid and Identify Potential Localized Area of Elevated Activity," USDOE Report EML-590 (1997)
- "An Application of the Maximum Entropy Method for Assessments of Residual Radioactivity at Contaminated Sites," IEEE Trans. Nucl. Sci. 43, 1837-1841 (1996)
- "*In Situ* Gamma-Ray Spectrometry - A Tutorial for Environmental Radiation Scientists," USDOE Report EML-557 (1995)
- "*In Situ* Gamma-Ray Spectrometry for the Measurement of Uranium in Surface Soils," Health Physics 67, 140-250 (1994)